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(56) Documents Cited
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(58) Field of Search
UK CL (Edition S) **F4R RCAA RCC RCEA RCGA RCK RFN**
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(54) Abstract Title
Electroluminscent lamp

(57) A lamp comprises electroluminescent elements 1, 14 (preferably an LED) which radiate photons in the visible or UV region from a central core 15 to the surface 6. This light passes by multiple routes and through various optically active layers or particles 7,17, 18 and 19 that modify the original radiation in direction, intensity, phase and spectrum in order to produce a useful light output for domestic, industrial, business or entertainment applications. The lamp provides an integral module that may be used as a contemporary light with standard connectors 12, 13. The lamp may comprise fluorescent coating 7, diffuser 17, semi-silver mirror 19, diffraction gratings, refractive particles, prisms, lenses, trapped gas particles and a translucent shell 6.

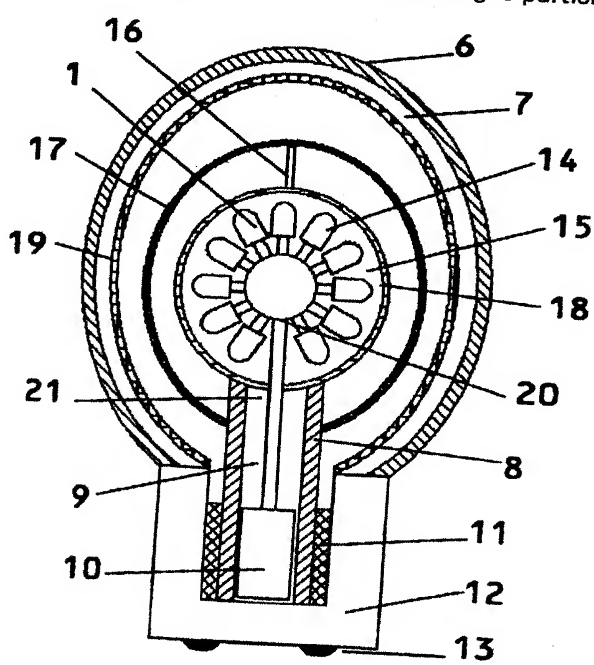

Figure 4

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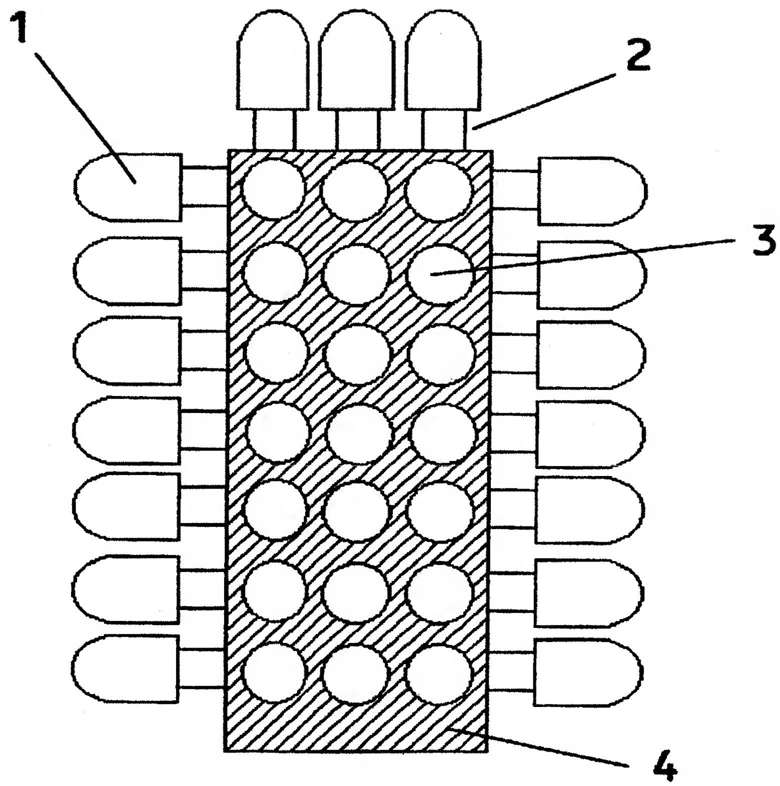

Figure 1

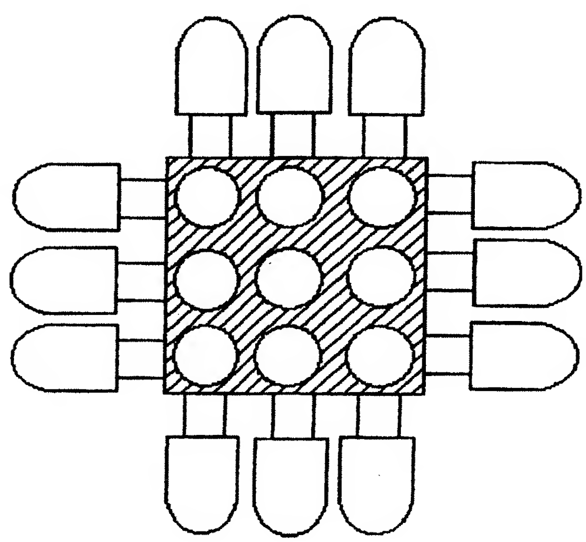

Figure 2

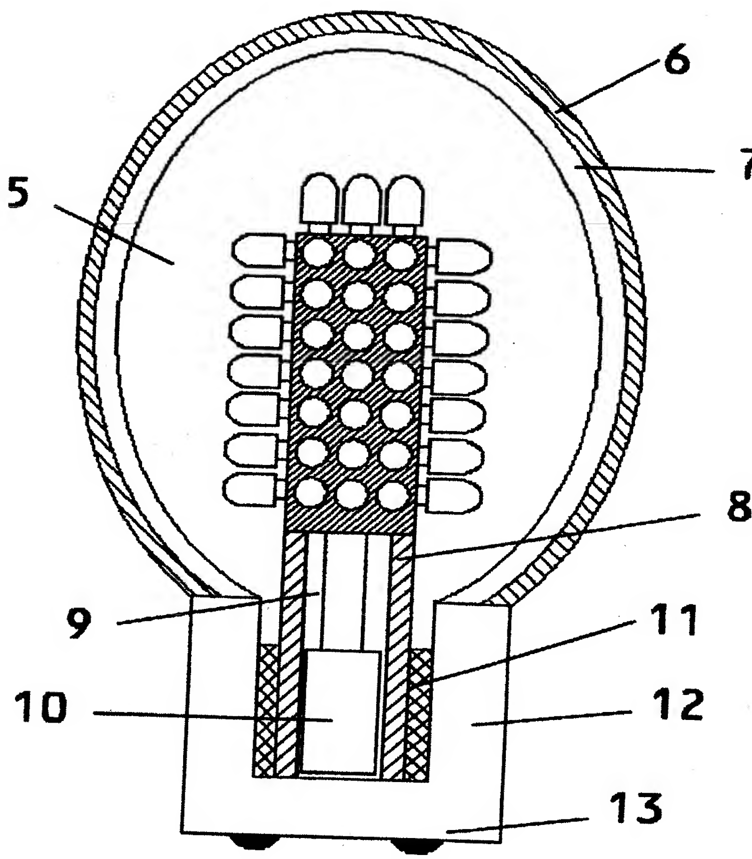

Figure 3

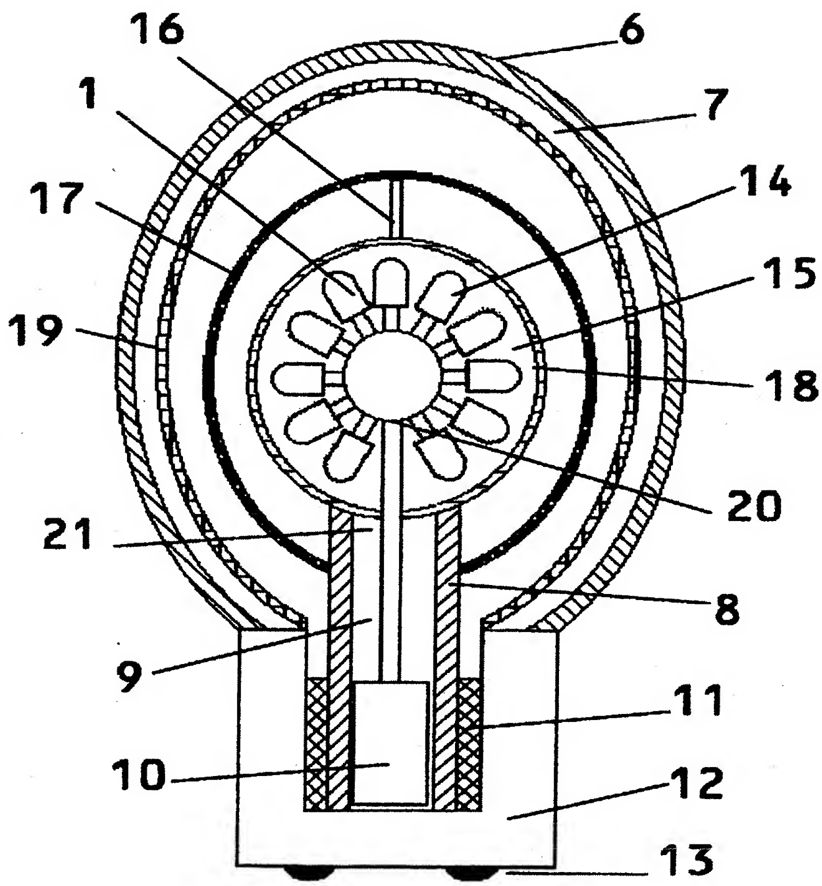

Figure 4

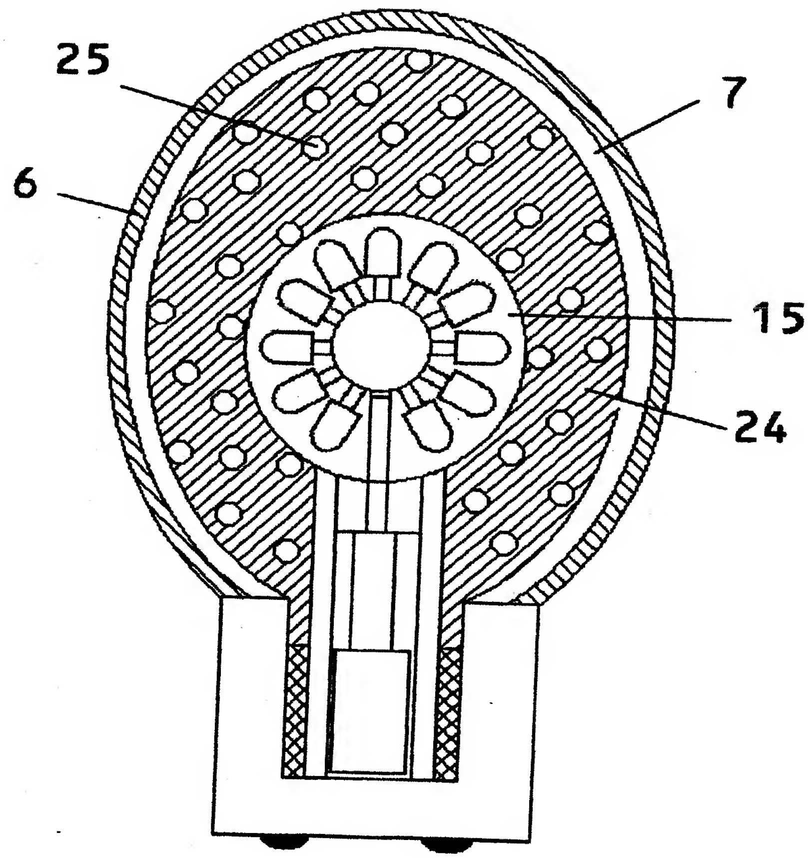

Figure 5

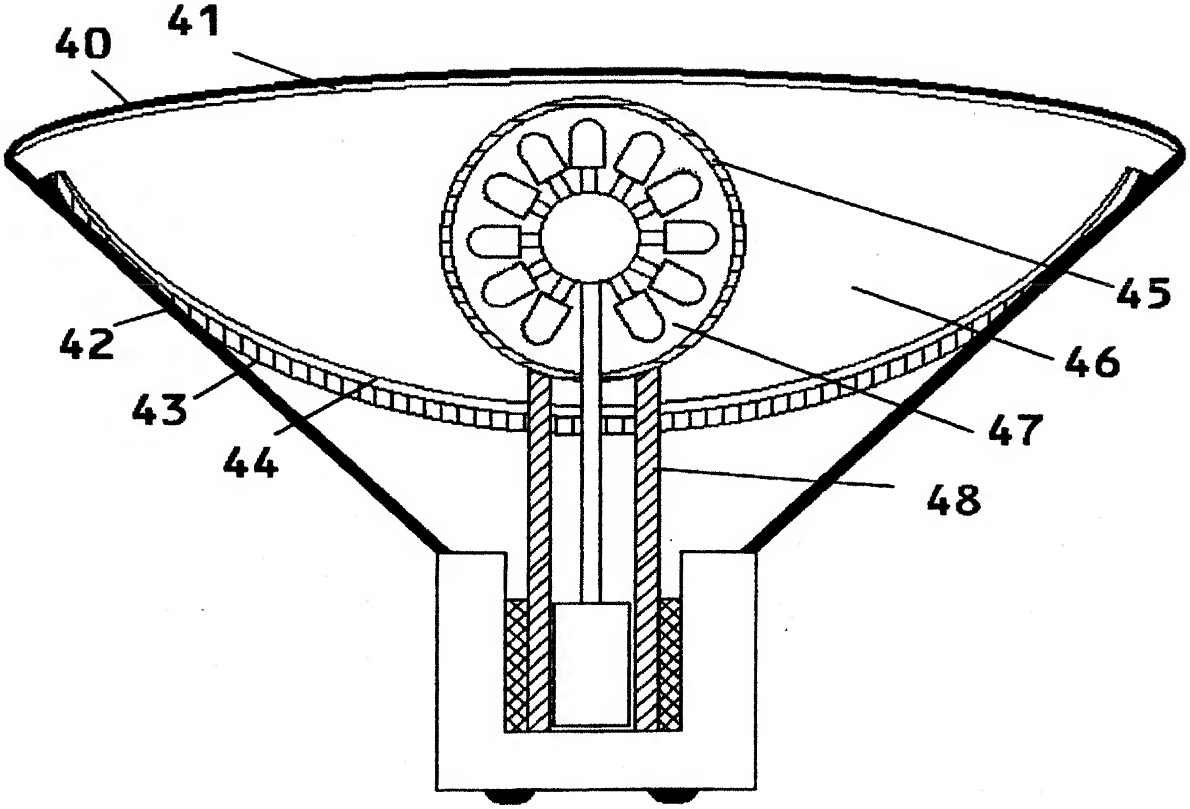

Figure 6

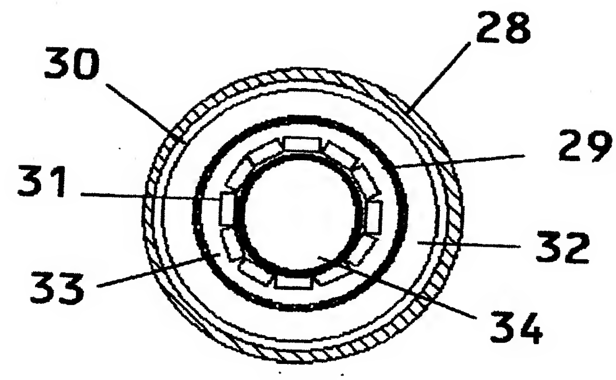

Figure 7

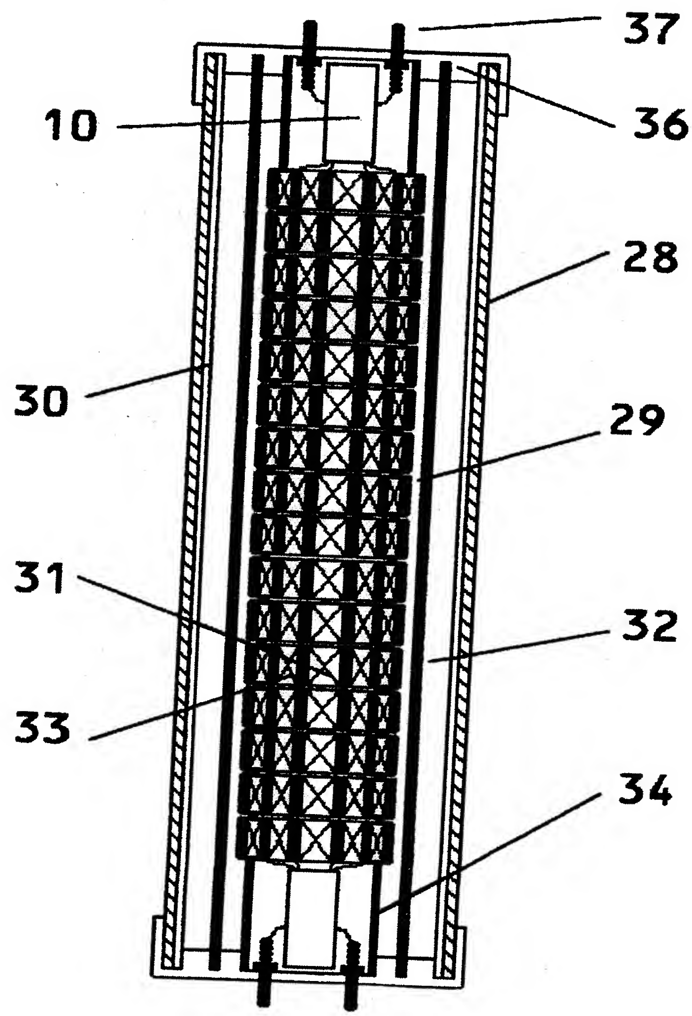

Figure 8

The present invention relates to a novel device for producing useful light from an electroluminescent device or devices.

The first electric light consisted of a carbon filament suspended in an evacuated glass bulb through which an electric current was passed causing it to become incandescent. Despite increasing sophistication filament bulbs have relatively short lives of a few hundred to a few thousand hours, are susceptible to vibration or shock and are fundamentally very inefficient.

Gas discharge tubes have largely replaced these in industrial applications and now increasingly at home as prices have fallen and the colour of the light output has improved. Discharge tubes contain a gas which is excited by an electric current resulting in the emission of photons at one or a number of wavelengths. These wavelengths may fall outside the visible spectrum, within the visible spectrum or both.

The most efficient is the low pressure sodium lamp which emits light at one wavelength only which is approximately the wavelength to which the human eye is most sensitive. However this light prevents us from distinguishing colours and is not suitable for many applications. By using different gases, pressures or mixtures of gases the colour produced can be varied.

In the ubiquitous fluorescent lamp much of the radiation from the gas discharge is in the ultraviolet range and thus invisible to the human eye. A coating of phosphor on the inside of the glass envelope is excited by the ultraviolet light and it glows. The spectrum of the output light can be adjusted by the mix of phosphor.

Discharge lamps require relatively complex accompanying circuitry. An electric arc must be struck; the discharge tube's resistance is high initially and then falls rapidly as the gas becomes ionised. In order to control the arc current a ballast is required. In most applications this is an inductor wired in series, although electronic ballast is used in some applications. This is often bulky and heavy. In addition it amounts to an inductive load. In industrial areas with large amounts of fluorescent or discharge lamp lighting significant fluctuation in power factor is observed that may require local correction by the electricity supply company. Fundamental disadvantages of these tubes including long warm up time during which the intensity and spectral output of the lamp varies. Their relative bulk is outweighed by their relative efficiency.

Recent advances in fluorescent tube technology has allowed wider acceptance of these bulbs into the domestic and industrial situation with the use of rapid-start electronic ballast and folded tubes. In spite of this they have yet to be widely accepted partly because the are large and do not fit into many light fittings. Little light is directed downwards because the base is wide and opaque and so do not work well in an upright lamp. Start-up time is still in the order of a minute and there is often a delay of a second or more before the arc is struck.

Until recently solid-state semiconductor technology has not been able to compete because few materials had been discovered which allowed the production of light with a wavelength of less than green at a cost compatible with widespread use . Silicon Carbide based blue light emitting diodes (LEDs) first appeared in 1991 but were very

inefficient and hence dim. Over the succeeding years advances in LEDs based on varying concentrations of Aluminium Indium Gallium Nitride which allow band-gap energies of 1.89eV (InN) to 6.2eV (AlN) resulting in emission of light from red to blue and ultraviolet. Now that these higher energy wavelengths are available the production of white light from solid-state devices is a reality. Current white-light LED technology is still dominated by the resin or plastic encapsulated light emitting chip operating in the blue or near-visible ultra-violet spectrum. A fluorescent ceramic(phosphor) or plastic may be used to modify the light output to produce peaks of emission in the red, green and blue areas of the spectrum. True white-light is not yet viable. The great majority of produced radiation exits the LED in a cone of light with a solid angle of somewhere between 15 and 60 degrees. The intensity of light across the projected zone is often variable and in some LEDs which produce multiple wavelengths there are rings or bands of different wavelengths due to refraction or other effects. More recent LED designs have incorporated a band of phosphor further away from the electroluminescent source but still within the LED to try and improve the uniformity of light. These modifications still do not fully address the problems of using electroluminescent materials for lighting applications.

LEDs have already been used in certain industrial applications for lighting. They are being used with increasing frequency for traffic signals, until recently only in red stop-lights due to the lack of suitable colours, where ultra-bright LEDs are mounted in an array pointing forward in one module. Other colours now follow. Other applications include long-lasting hand-held light sources, modules of white LEDs for direct replacement, medical light sources, computer and outdoor displays, brake lights, back-lighting and so on.

This invention, forthwith called a lamp, is primarily intended for illumination applications in domestic, industrial, business and entertainment situations and at a minimum would be able to provide a direct replacement for current lighting technology; however it is envisaged that it would not necessarily be limited to this application alone.

In parallel to the fluorescent light the innovative step of this lamp is the use of blue and/or ultraviolet electroluminescent devices (and other wavelengths if required) either singly or multiply to provide an electromagnetic energy source which can be reflected and/or refracted and/or diffracted and/or directed and/or scattered within the lamp before striking a fluorescent layer or vice-versa. Many variations on this theme are anticipated.

It will have the advantage of combining both efficiency and robustness. No delicate filaments or fragile low-pressure gas glass envelopes are required.

A device, forthwith referred to as a lamp, for producing electromagnetic radiation in the visible and/or near-visible region (the exact spectrum dependent upon requirements) consisting of an outer shell of transparent or translucent material of any shape and internally-mounted solid-state electroluminescent devices emitting in the visible or near visible electromagnetic spectrum where the light-path from the electroluminescent region(s) to the exterior surface is of sufficient length to allow the interposition of active and/or passive optical materials and/or devices and/or to allow the electromagnetic radiation to take multiple routes to sum at any given point on the surface; in this way the electromagnetic radiation from the surface of the lamp at any given point may be a function of both its position and time that is defined by the active and/or passive optical materials and devices and the light-paths.

An example of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig 1 Shows the side view of number of ultraviolet LEDs mounted facing outwards on a structure which has four sides and a top. Forthwith referred to as the LED core or electroluminescent device core.

Fig 2 Shows the top view of the same structure (LED core).

Fig 3 Shows the lamp in cross-section with the LED core mounted internally.

Referring to the drawings, the lamp consists of an outer shell of transparent material 6 which contains the ultraviolet LEDs (seen side on 1) and (seen end-on 3) mounted on their support structure 4 via their leads 2. This structure 4 provides both support and electrical connections and consists of a plastic circuit board on which electrical connections are formed from metal tracks. The LEDs 1 and 3 and the structure 4 forms the LED core.

The LED core is held in place by means of plastic supports 8 which are attached to the lamp base 12 by glue 11. Electrical connection is made to the LED array via wires 9 which connect to the internal control circuitry 10 which consists of active and passive electrical components controlling voltage and current to the LEDs.

The ultraviolet radiation passes via multiple light-paths through the air filled space 5 at ambient temperature and pressure and is converted by the fluorescent coating 7 on the inner surface of the lamp to visible radiation to produce white light.

A further example of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig 4. Illustrates another lamp in cross-section with various additional attributes.

Referring to the drawing, the lamp consists of an outer shell of translucent material 6 which contains the LED core. However in this core the ultraviolet LEDs 1 are arranged spherically so that each electroluminescent surface lies perpendicular to a line passing through the centre point. Some of the LEDs 14 are operating at a red wavelength for better colour output. The sphere is made in two halves with the LEDs initially supported by their own leads and electrical connections 20. The two halves are brought together and encapsulated in a resin 15 with the electrical connections 21 exiting towards the lamp base 12. The spherical LED core is carried by plastic supports 8 which are attached with glue 11. Electrical connection is made to the LED array via wires 9 which connect to the internal control circuitry 10 which consists of active and passive electrical components controlling voltage and current to the LEDs.

The surface of the resin LED core has been roughened slightly 18 to increase scattering of photons. A further translucent shell 17 acting as a diffuser consists of a transparent plastic shell in which small light-scattering particles of glass have been embedded. This is additionally supported by a small clear plastic rod 16.

The outer shell consists of a sandwich of an outer layer of transparent plastic 6 on the inside of which is coated a mixture of fluorescent materials 7 to convert the impinging blue and ultra-violet radiation into one or more visible wavelengths and an inner layer forming a semi-silvered mirror 19.

In this way the radiation travels via multiple light-paths through the air filled spaces impinging on various structures resulting in it being reflected and refracted. The final spectral output is dependent on the LED and phosphor mix.

Another example follows:

Fig 5 Demonstrates a lamp with further modifications.

Referring to the drawing, the lamp is similar to the previous example with an outer shell 6, phosphor coating 7 and a LED core 15. However the air-space 5 has been filled with a transparent plastic 24 which has been made translucent by the addition of fine particles 25 of a different refractive index.

A further example follows:

Fig 6 Illustrates a lamp with a mirror for use as a spotlight.

Referring to the drawing, tha lamp has a similar design but the transparent shell is formed into a truncated cone 42 with a slightly convex circular base 40 and the apex pointing towards the lamp base. The inner layer of the base is coated with a fluorescent material 41. The LED core 47 which is coated in a layer of light scattering particles 45 is mounted by way of metal legs 48 at the focus of a parabolic mirror which is formed from a sandwich two pieces of smooth transparent plastic 43 and a thin film of silver 44. The metal legs 48 have a dual purpose of providing support and of conducting heat away from the LED core such that the semiconductor junctions do not overheat.

In this way UV light exiting the LED core is scattered as it travels by multiple paths, some photons head directly out of the lamp while others are reflected from the mirror whence they are collimated into a forward beam.

A final example follows:

Fig 7 Shows a tubular lamp in cross-section

Fig 8 Shows a tubular lamp longitudinally. The LED core is shown in 3 dimensions but the rest is shown in cross-section.

Referring to the drawing this lamp is constructed from several concentric tubes which are help together by an end-cap 36. Electrical connections are made via all or some of the pins 37. Blue surface-mount LEDs (seen face-on 31 and seen at a 30° angle 33) are attached to the surface of a tubular support structure 34; initially made from a flat piece of flexible plastic and copper and subsequently rolled up. Connections to the LEDs are made via a wiring loom (not shown). The electrical ground for each LED is made through the support structure 34. LED power requirements are controlled by the circuitry 10. A plastic translucent concentric tube of larger diameter 29

surrounds the LED core which acts as a light diffuser. The spaces 32 between are filled with air maintained at ambient pressure by small communicating holes (not shown) with the outside. The lamp shell 28 is formed from a clear plastic tube mounted concentrically, its inner surface coated with a thin layer of fluorescent powder 30.

Light emitted from the LEDs is scattered by the tubular diffuser 29 and impinges on the fluorescent layer which converts some of the blue light to other lower frequencies to produce a white light.

Many possible variations exist to these basic designs which involve the use of different materials ceramics, metals, glass. plastic, other compounds or elements; different shapes or combinations of components; more or fewer layers of optically active materials in different arrangements; combinations of fluorescent and electroluminescent devices operating at different frequencies; various connectors, power requirements, power supplies and electrical control; varied methods of scattering, directing, focusing light including layers or particles of different refractive indices, sizes, shape, density, reflectivity, kinetic or damped elements.

CLAIMS

1. A device, forthwith referred to as a lamp, for producing electromagnetic radiation in the visible and/or near-visible region (the exact spectrum dependent upon requirements) consisting of an outer shell of transparent or translucent material of any shape and internally-mounted solid-state electroluminescent devices emitting in the visible or near visible electromagnetic spectrum where the light-path from the electroluminescent region(s) to the exterior surface is of sufficient length to allow the interposition of active and/or passive optical materials and/or devices and/or to allow the electromagnetic radiation to take multiple routes to sum at any given point on the surface; in this way the electromagnetic radiation from the surface of the lamp at any given point may be a function of both its position and time that is defined by the active and/or passive optical materials and devices and the light-paths.
2. A lamp as claimed in claim 1 where the lamp consists of internal ultraviolet and/or blue electroluminescent devices, a diffuser, a fluorescent layer an outer shell and base.
3. A lamp as claimed in any preceding claim where the electromagnetic spectrum emanating from any given area of the surface of the device may be modulated in time by activating the interposed optical devices or modulating the power to any of the internal electroluminescent devices.
4. A lamp as claimed in any preceding claim where the lamp components are arranged to minimise variations in spectra and luminosity across the surface.
5. A lamp as claimed in any preceding claim where the lamp components are arranged to accentuate variations in spectra and luminosity across the surface.
6. A lamp as claimed in any preceding claim with one or more mechanical connectors each with no, one or more electrical contacts.
7. A lamp as claimed in any preceding claim without a releasable connector but mounting points and electrical contacts or wires for permanent installation.
8. A lamp as claimed in any preceding claim which contains a power supply which may be either primary or secondary.
9. A lamp as claimed in any preceding claim with internal circuitry which allows individual light-producing devices to be controlled independently from one-another.
10. A lamp as claimed in any preceding claim with external circuitry which allows individual light-producing devices to be controlled independently from one-another.
11. A lamp as claimed in any preceding claim with traditional proportions and shape that would fit into standard light fittings such as a bulb, mushroom, tube or ring structure.
12. A lamp as claimed in any preceding claim with any shape of the external components.
13. A lamp as claimed in any preceding claim of any physical dimensions.
14. A lamp as claimed in any preceding claim which can be plugged directly into a light-fitting being matched for voltage and/or current and/or power requirements.
15. A lamp as claimed in any preceding claim which is optimised for efficiency.
16. A lamp as claimed in any preceding claim which is optimised for maximum light output.
17. A lamp as claimed in any preceding claim using square or rectangular mounted electroluminescent devices.
18. A lamp as claimed in any preceding claim using surface mount technology to facilitate close packing.

19. A lamp as claimed in any preceding claim with electroluminescent devices mounted in minimal amounts of material to facilitate closer packing.
20. A lamp as claimed in any preceding claim with any combination of electroluminescent plastics, polymers, semiconductors or lasers as the electroluminescent devices.
21. A lamp as claimed in any preceding claim with LED bars allowing significantly increased packing and luminosity.
22. A lamp as claimed in any preceding claim with multiple electroluminescent junctions in very close apposition (such as multiple junctions or quantum wells within one device) allowing very significantly increased packing and luminosity.
23. A lamp as claimed in any preceding claim having the electroluminescent devices pointing in limited directions.
24. A lamp as claimed in any preceding claim where the internal electroluminescent devices are mounted to form a complete or partial surface of any shape (such as a sphere, parallelepiped or pyramid.)
25. A lamp as claimed in any preceding claim where the internal electroluminescent devices are mounted in more than one layer.
26. A lamp as claimed in any preceding claim where there is more than one electroluminescent device core.
27. A lamp as claimed in any preceding claim where the electroluminescent device core(s) is(are) mounted eccentrically.
28. A lamp as claimed in any preceding claim where the electroluminescent device core is contained within the lamp base.
29. A lamp as claimed in any preceding claim where a mix of electroluminescent devices of differing spectral outputs are used to produce a selected spectral output.
30. A lamp as claimed in any preceding claim where the internal electroluminescent devices may contain their own phosphor and/or light diffusing materials.
31. A lamp as claimed in any preceding claim where a mix of phosphors are used to produce a selected spectral output.
32. A lamp as claimed in any preceding claim where the central array of electroluminescent devices is mounted in a supporting ground substance such as resin, plastic, glass, metal, ceramic, other compounds or elements.
33. A lamp as claimed in any preceding claim where the various layers of the lamp may occur in different orders such as having the fluorescent layer internal to the diffusing layer.
34. A lamp as claimed in any preceding claim where there are multiple layers of optically active areas or layers.
35. A lamp as claimed in any preceding claim where the optical surfaces are formed or altered by physical or chemical means or coated with optically active or fluorescent materials.
36. A lamp as claimed in any preceding claim where the surfaces of the light-emitting devices are altered by physical or chemical means or are coated with light dispersing or fluorescent materials in addition to their normal manufacture.
37. A lamp as claimed in any preceding claim where the diffusers consist of materials able to change the path of light.
38. A lamp as claimed in any preceding claim where the diffusers consist of ceramic, glass, plastic, metal, other compounds or elements in the form of particles or layers or roughened surfaces.

39. A lamp as claimed in any preceding claim where there is a gradation in the strength of the diffuser.
40. As above with an additional layer or layers of diffusing material.
41. As above with additional layers or particles of partially or fully reflective material.
42. A lamp as claimed in any preceding claim where the lamp is made of interleaved layers or areas of materials of differing optical qualities.
43. A lamp as claimed in any preceding claim where there is a gradient in optical characteristics such as number of particles per unit volume or refractive index or reflectivity.
44. A lamp as claimed in any preceding claim where the lamp contains fluid in which fluorescent, light dispersing or reflecting materials may be suspended or dissolved.
45. A lamp as claimed in any preceding claim where the lamp contains gas or a mixture of gases.
46. A lamp as claimed in any preceding claim where the lamp is essentially solid.
47. A lamp as claimed in any preceding claim where bubbles of gas are trapped in solid material.
48. A lamp as claimed in any preceding claim where optically active materials consist of glass, ceramic, plastic, metal other compounds or elements as gases, fluids or solids with varied refractive or reflective indices, diffractive or fluorescent or fluorescent properties or electro-optical behaviour such as voltage dependent birefringence.
49. A lamp as claimed in any preceding claim which contains single or multiple lenses, prisms or diffraction gratings.
50. A lamp as claimed in any preceding claim with where the optical devices are cooled actively or passively by means of fins, fans, coolants, supporting structures or heat-pipes or geometry of the lamp to improve heat transfer by convection, conduction and radiation.
51. A lamp as claimed in any preceding claim where the lamp's morphology is changeable using elastic, plastic, malleable or telescopic materials.
52. A lamp as claimed in any preceding claim where there is no external shell.
53. A lamp as claimed in any preceding claim where the external shell consists of ceramic, glass, plastic, metal, other compounds or elements.
54. A lamp as claimed in any preceding claim where external surface of the lamp acts as a diffuser, lens or has other optical characteristics.
55. A lamp as claimed in any preceding claim where the internal pressure is not equal to ambient pressure.
56. A lamp as claimed in any preceding claim where the internal structures of the lamp may move in relation to one another either actively by a motor or passively by elastic or plastic supports.
57. A lamp as claimed in any preceding claim where internal structures are mechanically damped.
58. A lamp as claimed in any preceding claim where the support structure comprises both electrical supply and mechanical support.
59. A lamp as claimed in any preceding claim where the support structure is separate to the electrical connections which may be made by wires or specialised separate circuit board.
60. A lamp as claimed in any preceding claim where the support structure consists of ceramic, glass, plastic, metal, other compounds or elements.
61. A lamp as claimed in any preceding claim where the support structure consists of a combination of materials.
62. A lamp as claimed in any preceding claim where there is more than one support structure.
63. A lamp as claimed in any preceding claim where there is no support structure.

64. A lamp as claimed in any preceding claim where the various parts are screwed, bolted, fastened, glued, welded, snap-fitted or soldered together.

65. A lamp as claimed in any preceding claim where thermoplastic or thermoset materials are used.

66. A lamp as claimed in any preceding claim where light is reflected from one or more mirrors of any shape within the lamp.

67. A lamp as claimed in any preceding claim where a mirror is used to spread or collimate the light.

68. A lamp as claimed in any preceding claim where the lamp is waterproof.

69. A lamp as claimed in any preceding claim where at least one layer of the lamp has low permeability to a specific gas or gases either to allow gases to be retained within part of the lamp or to prevent gases entering.

70. A lamp substantially as described herein with reference to the figures 1 to 8 and the preceding claims.

The Patent Office

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Application No: GB 0021892.5
Claims searched: 1-70

Examiner: Darren Handley
Date of search: 22 January 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.S): F4R (RFN, RCGA, RCEA, RCAA, RCK, RCC)
Int Cl (Ed.7): H05B 33/00, 33/02
Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0876085 A2	(INCERTI) - see column 1, line 43- column 2, line 55.	1, 4, 6-9, 11-16, 23, 28, 32-35, 37-41, 43, 45, 46, 53, 54, 58, 60, 64, 65, 68
X	US 5535230 A	(ABE) - whole document relevant.	1-4, 6-8, 10-24, 26, 29, 30, 32-38, 40, 45, 49, 50, 53, 55, 58, 60, 64, 65
X	US 4975814 A	(SCHAIRER) - see square LEDs 1 and reflectors 3, figure 4.	1, 4, 6-8, 10, 12, 13, 15-20, 23, 24, 32, 36, 46, 53 59, 60, 64-67

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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INVESTOR IN PEOPLE

Application No: GB 0021892.5
Claims searched: 1-70

Examiner: Darren Handley
Date of search: 22 January 2001

Category	Identity of document and relevant passage		Relevant to claims
X	JP 100074401 A	(DENKOSHA) - see coloured plastic rings 10A-J, figure 1 and WPI abstract AN 1998-236281 [21].	1, 3, 5, 6, 8, 9, 11-13, 15, 16, 20, 23, 24, 32, 46, 60, 65
X	JP 100040702 A	(OGAWA) - see layers 6 and 7, figure 1 and WPI abstract AN 1998-184980 [17].	1, 3, 4, 6, 8, 9, 11-16, 20, 23, 30, 32-34, 37, 38, 41, 45, 46, 53, 58, 60, 64, 65
X	JP 080127297 A	(SEKISUI) - see beads 4 in resin 3, figure 1 and WPI abstract AN 1996-295309 [30].	1, 4, 6-8, 10, 12, 13, 15, 16, 20, 32, 35, 47, 53, 63, 68
X	JP 020106801 A	(STANLEY) - see lens 6 and prisms 7, 8, figure 2 and PAJ abstract.	1, 4, 6, 8, 9, 12, 13, 15, 16, 20, 23, 24, 32-34, 37, 38, 46, 49, 53, 60, 64, 65

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family.	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.